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Devore et al.

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(54) **FULL COVERAGE TRAILING EDGE
MICROCIRCUIT WITH ALTERNATING
CONVERGING EXITS**

USPC 415/115; 416/97 R
See application file for complete search history.

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(52) **U.S. Cl.**
CPC **F01D 5/187** (2013.01); **F05D 2240/122**
(2013.01); **F05D 2240/304** (2013.01)

(58) **Field of Classification Search**
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F05D 2240/304; F05D 2260/202; F05D
2260/204; F02C 7/12

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,328,331 A 7/1994 Bunker et al.
2005/0281667 A1* 12/2005 Liang 415/115
2008/0050243 A1 2/2008 Liang

FOREIGN PATENT DOCUMENTS

EP 1091092 A2 4/2001
EP 1847684 A1 10/2007

* cited by examiner

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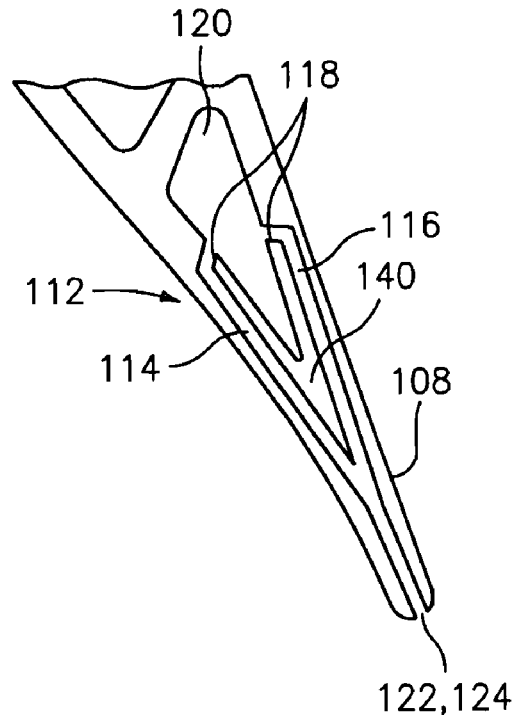
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(57) **ABSTRACT**

A turbine engine component has an airfoil portion with a pressure side wall, a suction side wall, and a trailing edge. The turbine engine component further has at least one first cooling circuit core embedded within the pressure side wall, with each first cooling circuit core having a first exit for discharging a cooling fluid, at least one second cooling circuit core embedded within the suction side wall, with each second cooling circuit core having a second exit for discharging a cooling fluid, and the first and second exits being aligned in a spanwise direction of the airfoil portion.

18 Claims, 4 Drawing Sheets



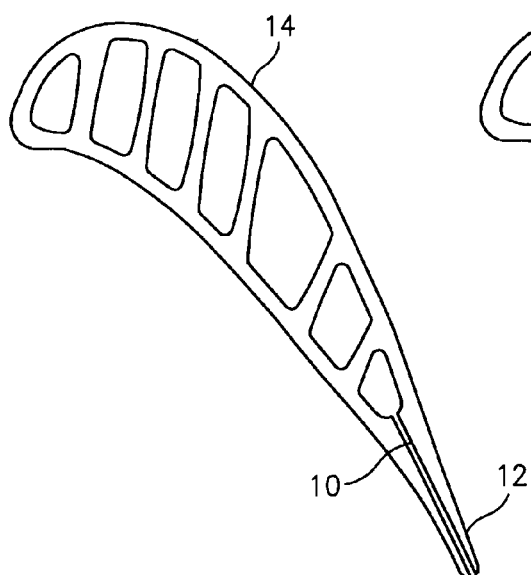


FIG. 1
(PRIOR ART)

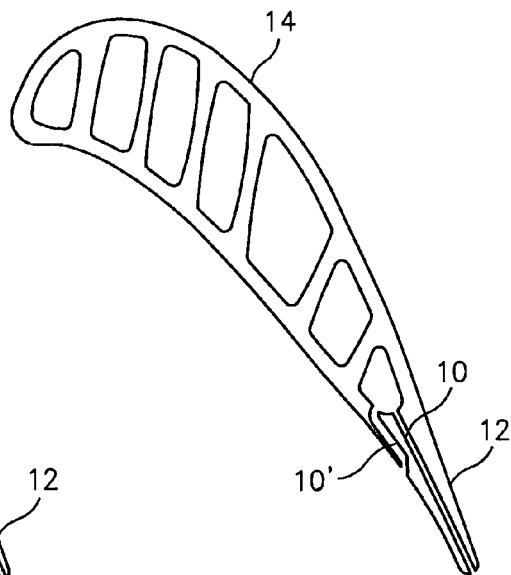


FIG. 2
(PRIOR ART)

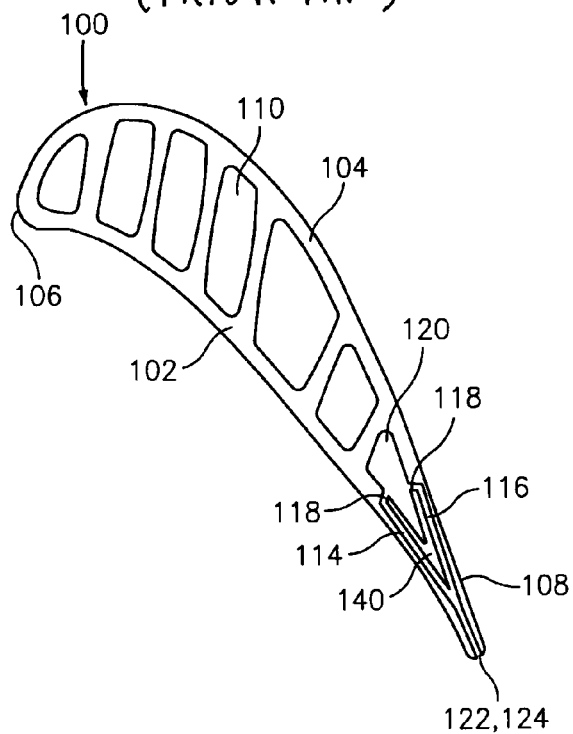


FIG. 3

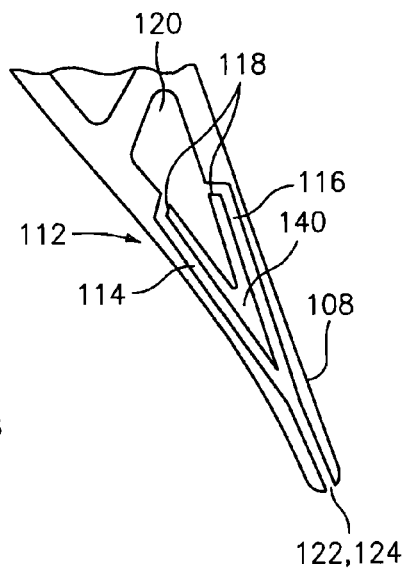


FIG. 4

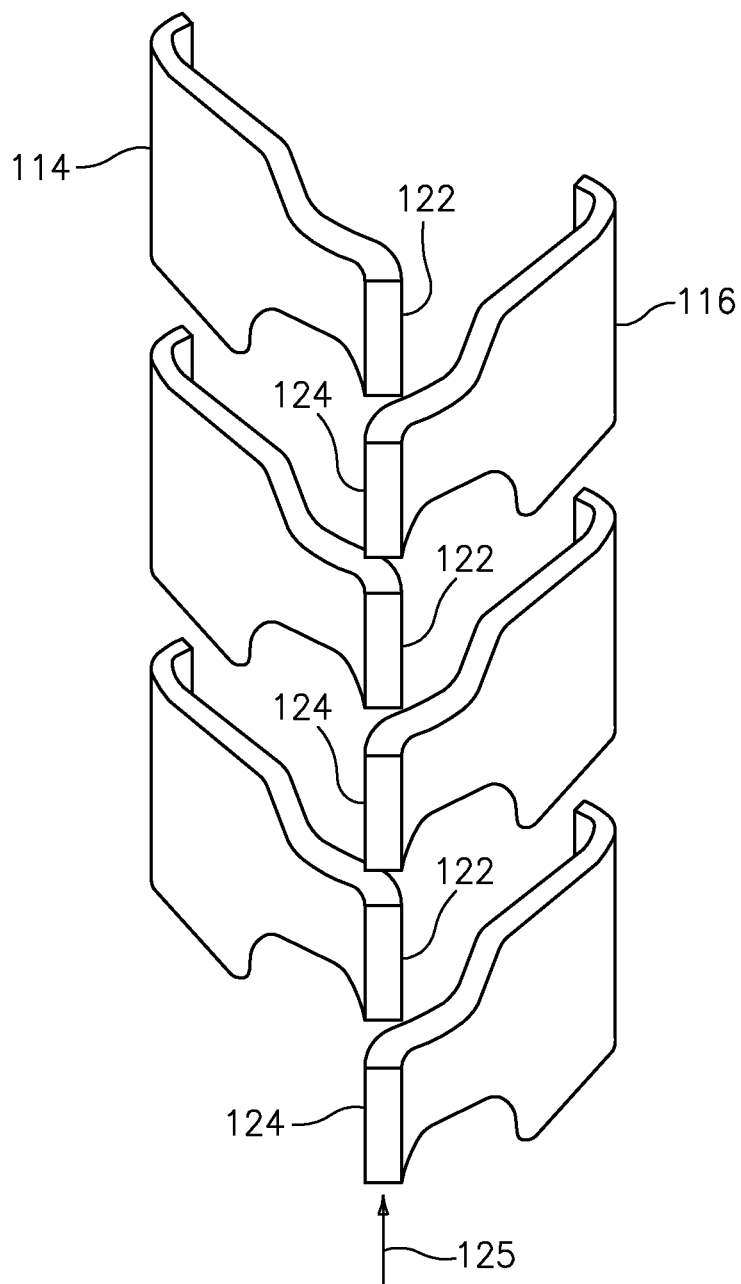


FIG. 5

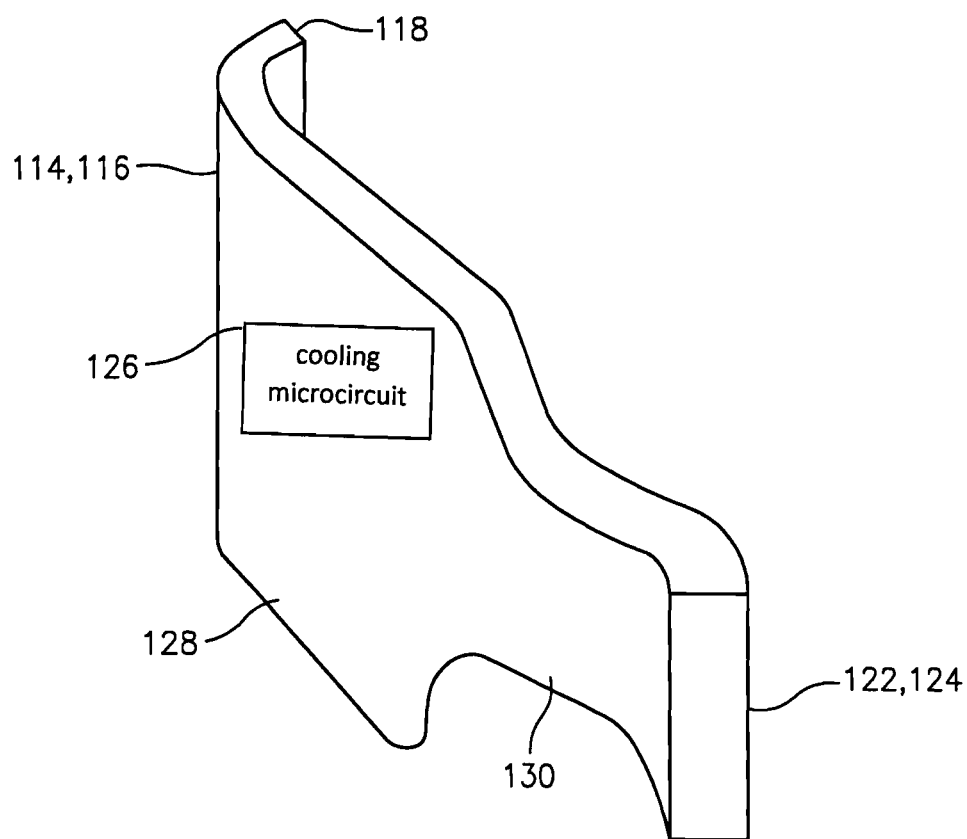


FIG. 6

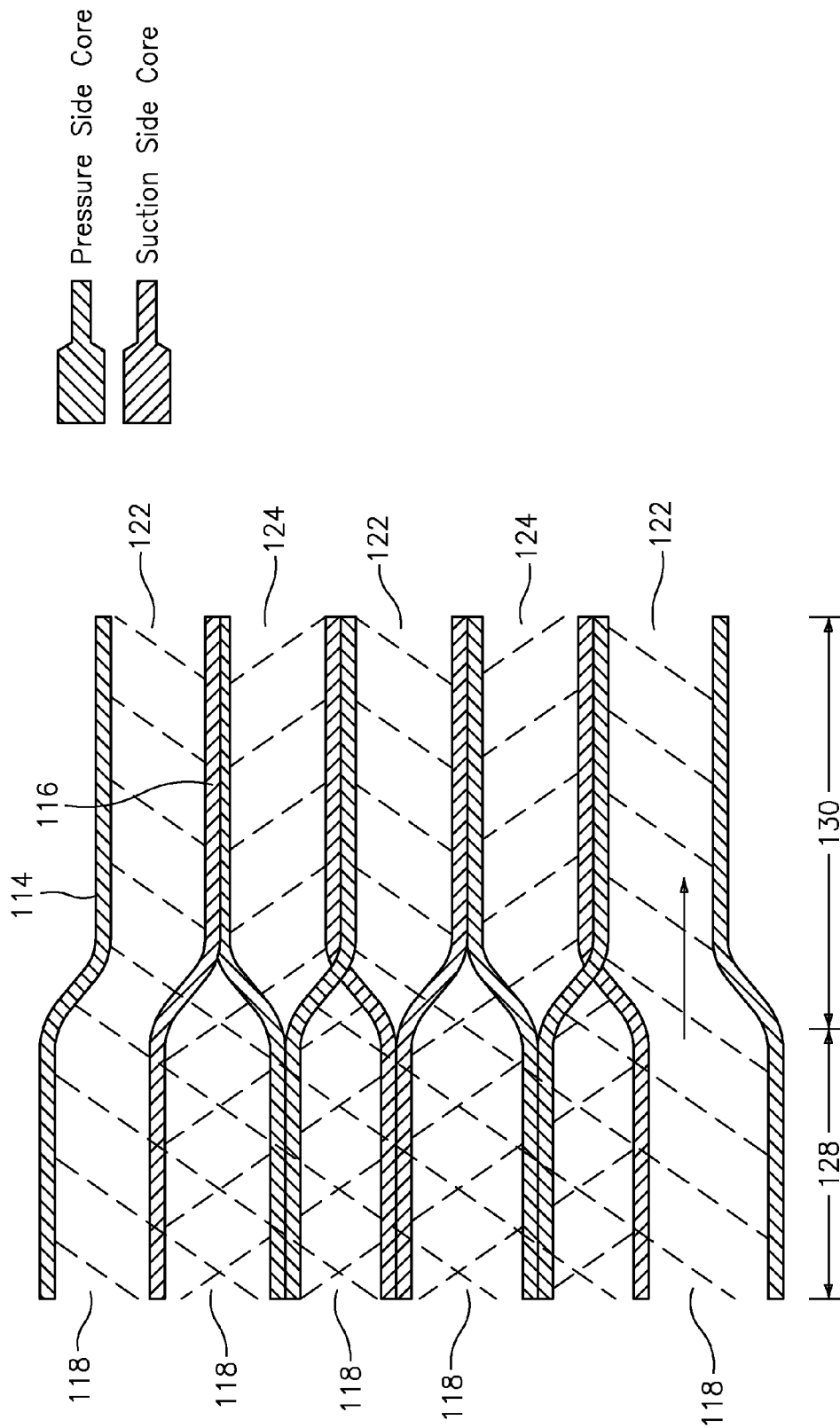


FIG. 7

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FULL COVERAGE TRAILING EDGE MICROCIRCUIT WITH ALTERNATING CONVERGING EXITS

BACKGROUND

The present application is directed to an airfoil portion of a turbine engine component.

Some existing trailing edge microcircuits consist of a single core **10** inserted into a mainbody core and run out the center of a trailing edge **12** of an airfoil portion **14** of a turbine engine component, or to a pressure side cutback (see FIG. 1). Other schemes run two cores **10** and **10'** out the aft end of the trailing edge **12** (see FIG. 2) of the airfoil portion **14**. Of the two microcircuits in this configuration, one behaves similar to other trailing edge microcircuits while the other dumps to the pressure side upstream of the trailing edge.

SUMMARY OF THE INVENTION

A turbine engine component having an airfoil portion with a pressure side wall, a suction side wall, and a trailing edge is described herein. The turbine engine component comprises at least one first cooling circuit core embedded within the pressure side wall, each said first cooling circuit core having a first exit for discharging a cooling fluid, at least one second cooling circuit core embedded within the suction side wall, each said second cooling circuit core having a second exit for discharging a cooling fluid, and said first and second exits being aligned in a spanwise direction of said airfoil portion.

Also described herein is a process for forming a turbine engine component. The process broadly comprises the steps of forming an airfoil portion having a pressure side wall, a suction side wall, and a trailing edge, forming a trailing edge cooling system which comprises at least one first cooling circuit core within said pressure side wall and at least one second cooling circuit core having within said suction side wall, and forming said at least one first cooling circuit core to have a first exit and forming said at least one second cooling circuit core to have a second exit aligned with said first exit in a spanwise direction of said airfoil portion.

Other details of the invention, as well as other objects and advantages attendant thereto are set forth in the following detailed description and the accompanying drawings, wherein like reference numerals depict like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a first embodiment of a trailing edge microcircuit scheme;

FIG. 2 illustrates a second embodiment of a trailing edge microcircuit scheme;

FIG. 3 illustrates an airfoil portion of a turbine engine component with a new and useful embodiment of a trailing edge microcircuit scheme;

FIG. 4 is an enlarged view of the trailing edge microcircuit scheme of FIG. 3;

FIG. 5 is a 3-D drawing showing an example of the trailing edge microcircuit of FIG. 3;

FIG. 6 illustrates the features of an individual microcircuit used in the scheme of FIG. 3; and

FIG. 7 illustrates the alternating trailing edge exits of the trailing edge microcircuits.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

FIGS. 3 and 4 illustrate an airfoil portion **100** of a turbine engine component such as a turbine blade or vane. The airfoil

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portion **100** has a pressure side wall **102** and a suction side wall **104**. The airfoil portion **100** also has a leading edge **106** and a trailing edge **108**. The airfoil portion **100** when formed has a number of cooling circuit cores **110** through which cooling fluid may flow to a number of microcircuits (not shown) embedded into the pressure and suction side walls **102** and **104**.

As can be seen from FIGS. 3 and 4, the airfoil portion **100** also has a trailing edge microcircuit or cooling system **112** for cooling the trailing edge **108** of the airfoil portion. The microcircuit **112** may be characterized by at least one pressure side cooling circuit core **114** embedded within the pressure side wall **102** and at least one suction side cooling circuit core **116** embedded within the suction side wall **104**. Each said cooling circuit core **114** and **116** has an inlet **118** which communicates with a source of cooling fluid, such as engine bleed air. For example, each inlet **118** may communicate with a central core **120** through which flows the cooling fluid. Further, each pressure side cooling circuit core **114** has an exit **122**, while each suction side cooling circuit core **116** has an exit **124**.

As can be seen from FIGS. 3 and 4, both cooling circuit cores **114** and **116** exit in the same location, such as a center discharge or a cutback trailing edge. This may be accomplished by converging, or narrowing the microcircuit cores **114** and **116** in a radial direction, and alternating the exits **122** and **124** as shown in FIG. 5. Further, as shown in FIG. 5, the exits **122** and **124** may be aligned in a spanwise direction **125** of the airfoil portion **100**.

FIG. 6 shows the possible features of each one of the cooling circuit cores **114** and **116**. As can be seen from this figure, each cooling circuit core **114** and **116** may have an inlet **118**, a cooling microcircuit **126** which may comprise any suitable cooling microcircuit such as an axial pin fin array microcircuit, a non-convergent section **128**, a convergent section **130**, and a trailing edge exit **122** or **124**.

FIG. 7 shows a staggered arrangement of the pressure side cores **114** and the suction side cores **116** which leads to the alternating trailing edge exits **122** and **124**. This figure also shows the non-convergent section **128** and the convergent section **130**.

As shown in FIG. 3, the pressure side core(s) **114** and the suction side core(s) **116** converge towards each other. A wedge **140** may be positioned between the converging core(s) **114** and **116**.

Each cooling circuit core **114** and **116** may be fabricated using any suitable technique known in the art. For example, each of the cooling circuit cores **114** and **116** may be formed using refractory metal core technology in which the airfoil portion **100** is cast around the refractory metal cores and after solidification, the refractory metal cores are removed.

The full coverage trailing edge microcircuit with alternating converging exits described herein should provide several aero-thermal benefits. As can be seen from the foregoing description, the pressure and suction side walls of the airfoil portion **100** are fully covered. Additionally, heat is only being drawn into each microcircuit from a single hot wall in the non-converging zone **128**. The opposite side of each core is shielded by the opposite wall core. In the convergent section **130** of each core, heat is drawn from both hot walls. The trailing edge provides a low-pressure sink for flow to be discharged. Due to the significant pressure ratio across each core, substantial convective heat transfer can be achieved by dumping flow out in this location. Because the cooling circuit cores **114** and **116** converge at the trailing edge, Mach numbers in the passage should increase as they reach the end of the circuit. This Mach number increase should increase the flow per unit area in the core and thus should increase internal heat

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transfer coefficients. Conversely, the non-convergent portion **130** of the microcircuit should produce lower heat transfer coefficients and thus likely reduce the amount of heat-up in this region of the airfoil portion **100**. Because external heat loads should increase externally as one move aft along the airfoil portion **100**, the cooling scheme described herein provides a balance of low heat up/low heat transfer in the beginning of the circuit, moving to high heat up/high heat transfer at the end of the circuit. Thus, this configuration provides for an improved heat transfer, which will result in a cooler, more isothermal trailing edge. There should also be an aerodynamic benefit to the high Mach number at the core exits **122** and **124**. The high exit velocity of the coolant better matches the external free stream velocity and thus should reduce aerodynamic mixing losses.

Additional structural benefits may exist from the wedge **140** (see FIGS. **3** and **4**) of the metal left between the two trailing edge cores **114** and **116** after the cores **114** and **116** have been formed. This internal wedge **140** may provide stiffness to the trailing edge to combat creep and help dampen vibrations. If desired, the cores **114** and **116** and/or the microcircuits can be altered to change the shape of the trailing edge internal wedge **140**.

The invention may also increase the thermal effective of the airfoil portion in which it is incorporated, while reducing the required cooling air discharged into the gas path and the aforementioned aerodynamic losses.

While the core **116** has been shown as originating from the suction side of mainbody core as depicted in FIGS. **3** and **4**, it may connect with mainbody core in a manner similar to the centered microcircuit **10** in FIG. **1** and then weave with the core **114**.

It is apparent that there has been provided an inventive microcircuit design. Other unforeseeable alternatives, modifications, and variations may become apparent to those skilled in the art having read the foregoing description. Accordingly, it is intended to embrace those alternatives, modifications, and variations as fall within the broad scope of the appended claims.

What is claimed is:

1. A turbine engine component having an airfoil portion with a pressure side wall, a suction side wall, and a trailing edge, said component comprising:

at least one first cooling circuit core embedded within the pressure side wall;

each said first cooling circuit core having a first exit for discharging a cooling fluid;

at least one second cooling circuit core embedded within the suction side wall;

each said second cooling circuit core having a second exit for discharging a cooling fluid; and

said first and second exits being aligned in a spanwise direction of said airfoil portion,

wherein each of said first and second cooling circuit cores has a cooling microcircuit, a non-convergent section adjacent said cooling microcircuit, and a spanwise convergent section adjacent said non-convergent section.

2. The turbine engine component according to claim **1**, further comprising a plurality of first cooling circuit cores embedded within the pressure side wall and a plurality of second cooling circuit cores embedded within the suction side wall and a plurality of first exits and a plurality of second exits being aligned in said spanwise direction.

3. The turbine engine component according to claim **1**, wherein said first and second exits exit in a location in a center of the trailing edge.

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4. The turbine engine component according to claim **1**, wherein said first and second exits exit in a location which is a cutback trailing edge.

5. The turbine engine component according to claim **1**, wherein each said first cooling circuit core converges towards each said second core.

6. The turbine engine component according to claim **5**, further comprising a wedge located between said at least one first cooling circuit core and said at least one second cooling circuit core.

7. The turbine engine component according to claim **1**, wherein each said first cooling circuit core has a first inlet for receiving cooling fluid and each said second cooling circuit core has a second inlet for receiving cooling fluid.

8. The turbine engine component according to claim **7**, wherein each said first inlet and each said second inlet receive said cooling fluid from a common source.

9. The turbine engine component according to claim **1**, wherein said convergent section in each said first cooling circuit core is located adjacent each said first exit and wherein said convergent section in each said second cooling circuit core is located adjacent each said second exit.

10. A process for forming a turbine engine component comprising the steps of:

forming an airfoil portion having a pressure side wall, a suction side wall, and a trailing edge;

forming a trailing edge cooling system which comprises at least one first cooling circuit core within said pressure side wall and at least one second cooling circuit core having within said suction side wall;

forming said at least one first cooling circuit core to have a first exit and forming said at least one second cooling circuit core to have a second exit aligned with said first exit in a spanwise direction of said airfoil portion; and

forming each of said first and second cooling circuit cores with a cooling microcircuit, a non-convergent section adjacent said cooling microcircuit, and a convergent section having a portion which converges in a spanwise direction adjacent said non-convergent section.

11. The process according to claim **10**, wherein said trailing edge cooling system forming step comprises forming a plurality of first cooling circuit cores embedded within the pressure side wall and forming a plurality of second cooling circuit cores embedded within the suction side wall and forming a plurality of first exits and a plurality of second exits aligned in said spanwise direction.

12. The process according to claim **10**, wherein said forming step further comprises forming said first and second exits to exit at a center of the trailing edge.

13. The process according to claim **10**, wherein said forming step further comprises forming said first and second exits to exit at a cutback trailing edge.

14. The process according to claim **10**, wherein said forming step comprises forming each said first cooling circuit core to converge towards each said second cooling circuit core.

15. The process according to claim **14**, further comprising forming a wedge between said at least one first cooling circuit core and said at least one second cooling circuit core.

16. The process according to claim **10**, further comprising forming each said first cooling circuit core with a first inlet for receiving cooling fluid and each said second cooling circuit core with a second inlet for receiving cooling fluid.

17. The process according to claim **16**, further comprising arranging each said first inlet and each said second inlet so as to receive said cooling fluid from a common source.

18. The process according to claim **10**, further comprising locating said convergent section in each said first cooling

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circuit core adjacent each said first exit and locating said
convergent section in each said second cooling circuit core
adjacent each said second exit.

* * * * *

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